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Columbia University

in the city of new york

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Context

Assignments

Android Virtual Lab

Demos

Student Response

The Course

The Course

- one semester introductory OS

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- graduate / advanced undergrad

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- students familiar with C

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- teams of 2-3 students

Android

Android

- uses Linux kernel: familiar transition path

Android

- leverages wealth of Linux tools/documentation

Android

- open source (mostly)

Android

- production system

Android

- fastest growing mobile platform to date

Android

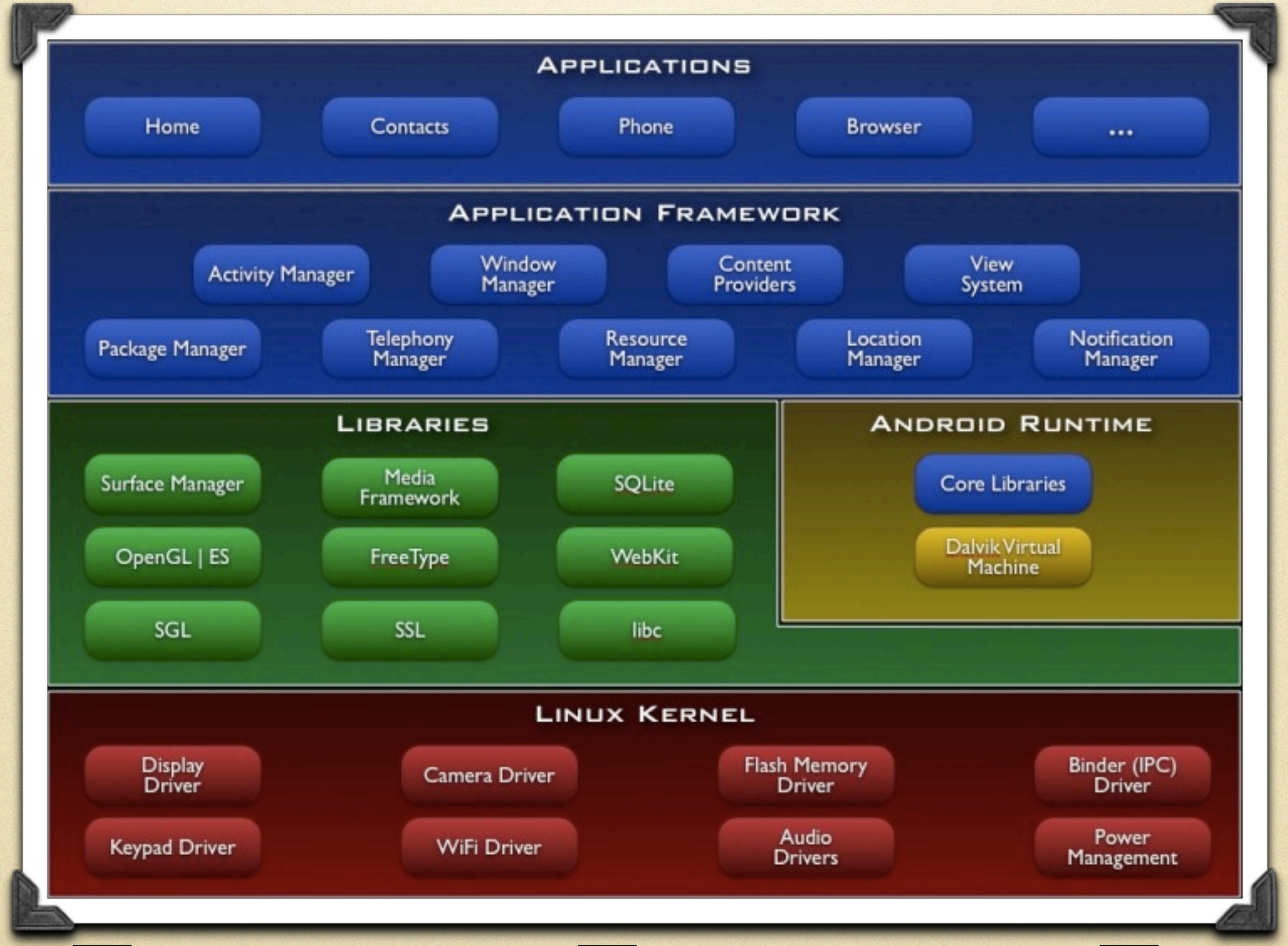
- commercially supported

Android

- hacking your phone is cool

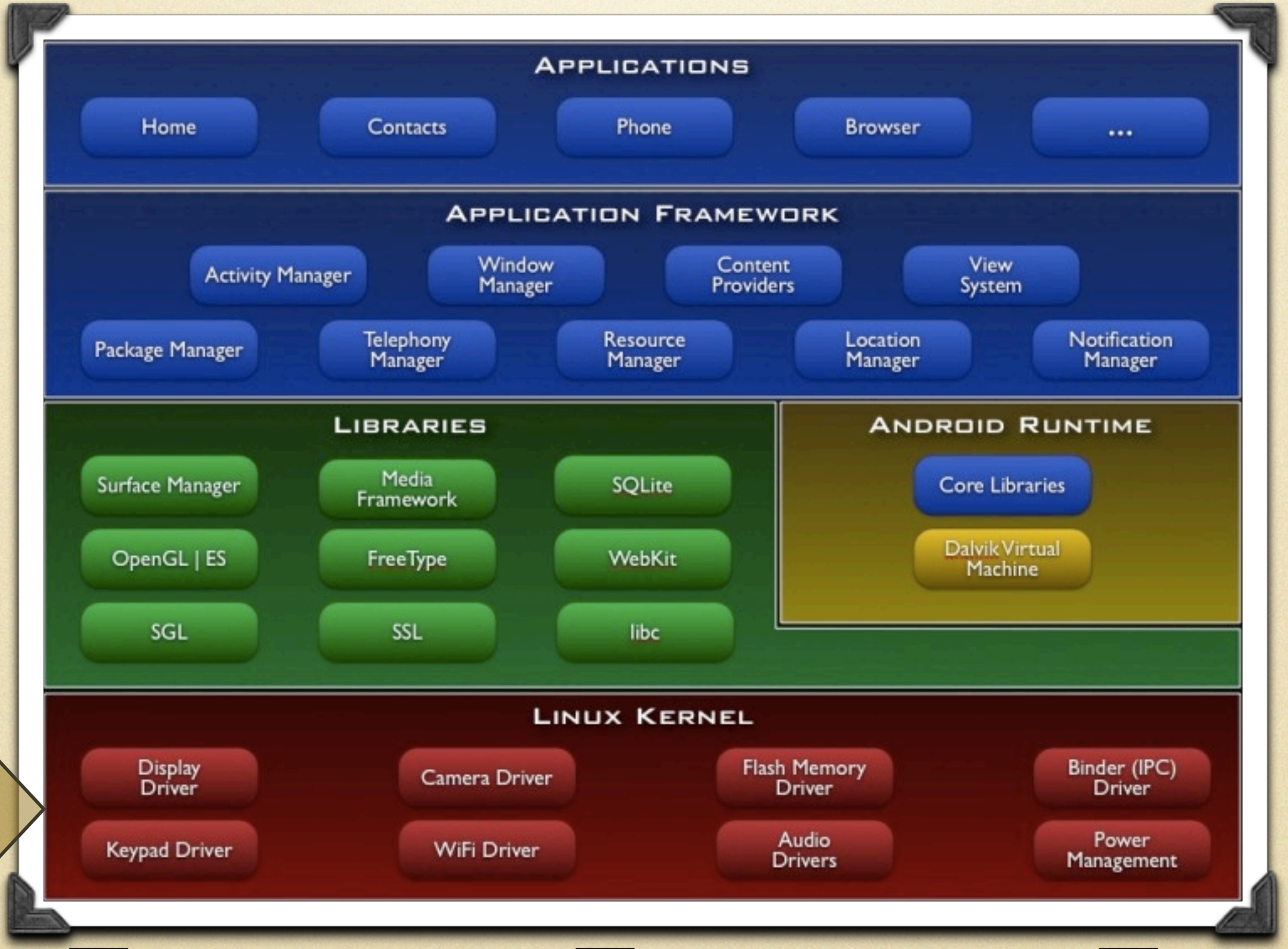
Android Inside

Android Inside



OS: C C/C++ Java

Android Inside



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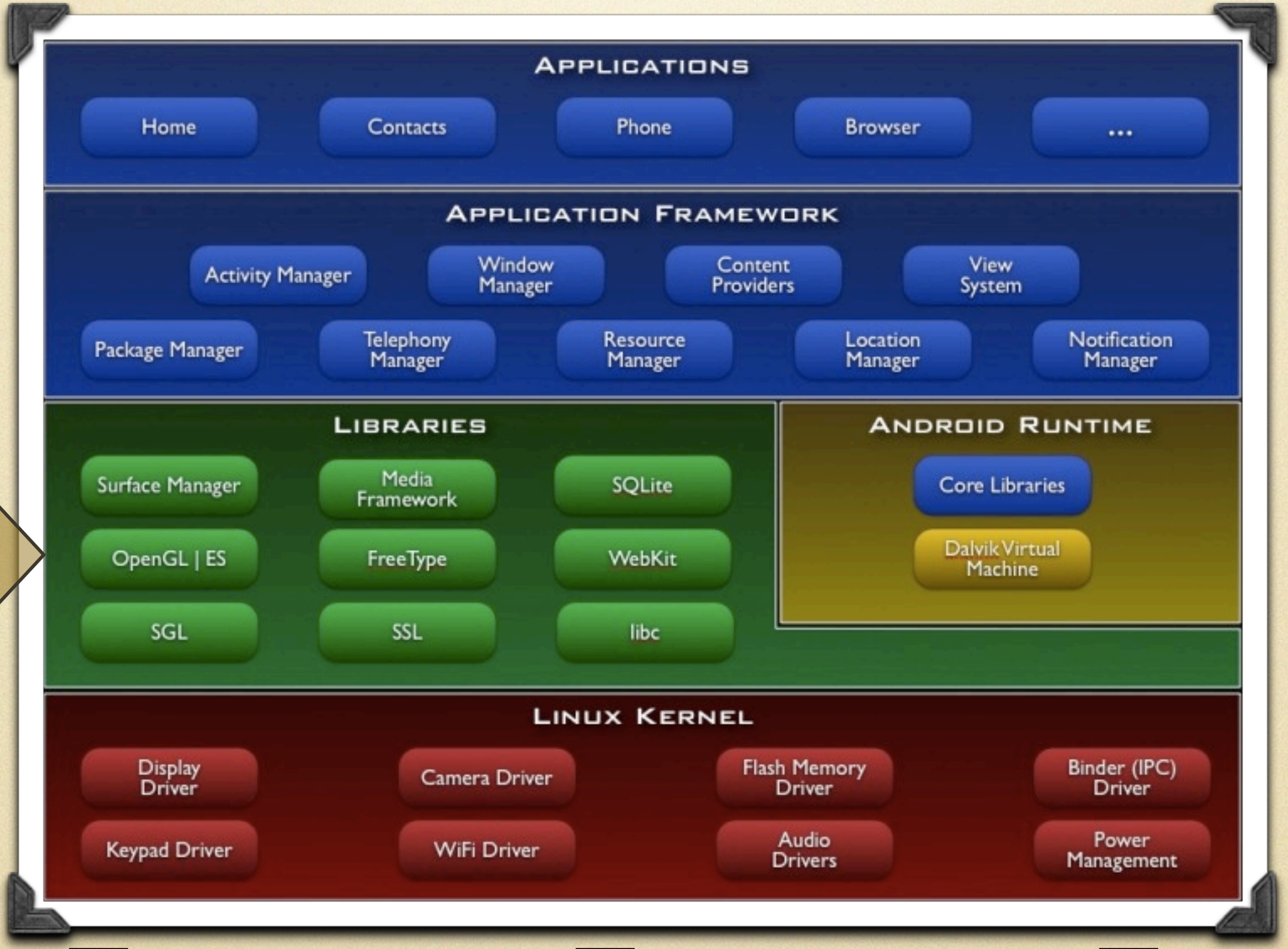

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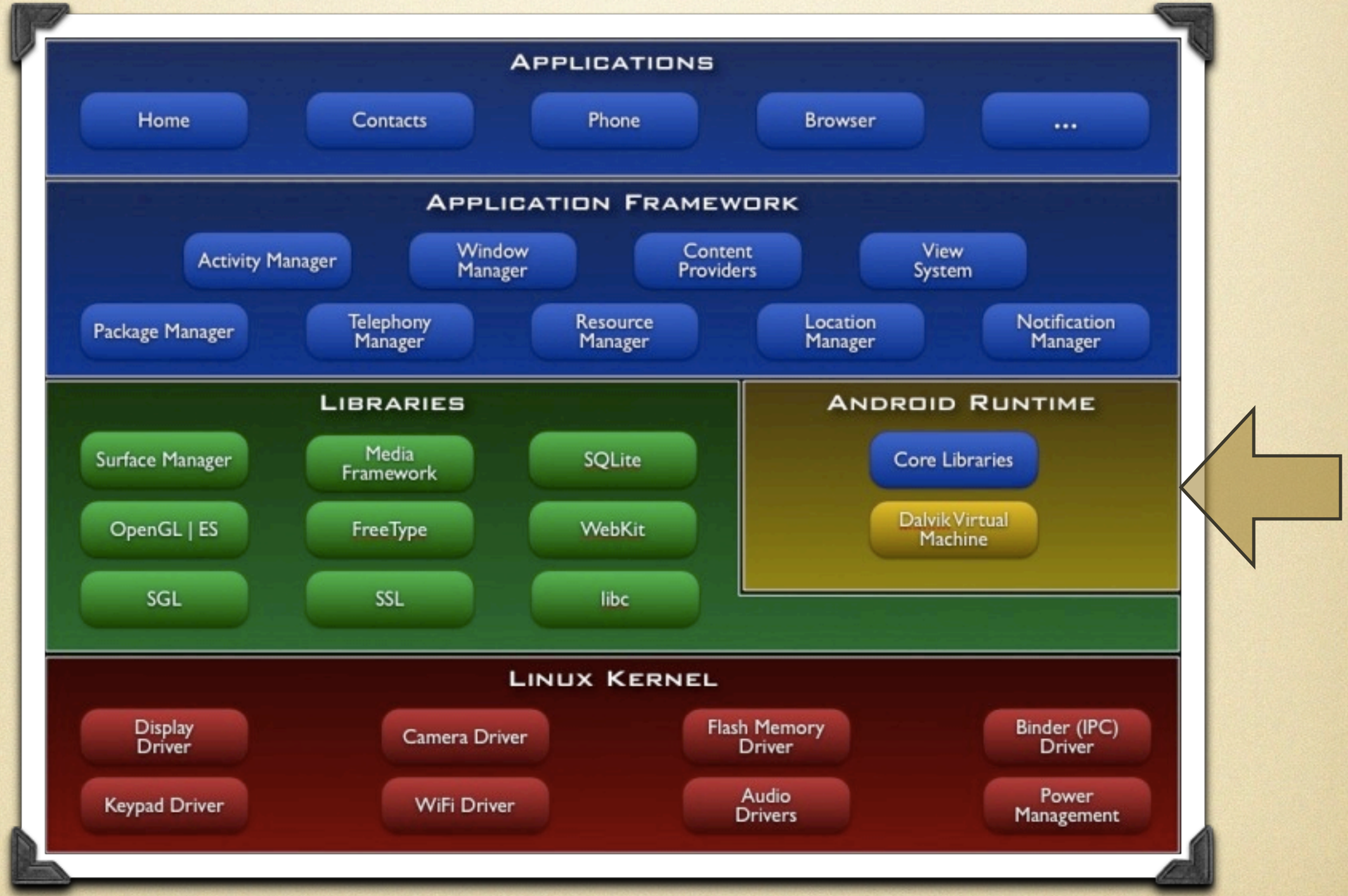

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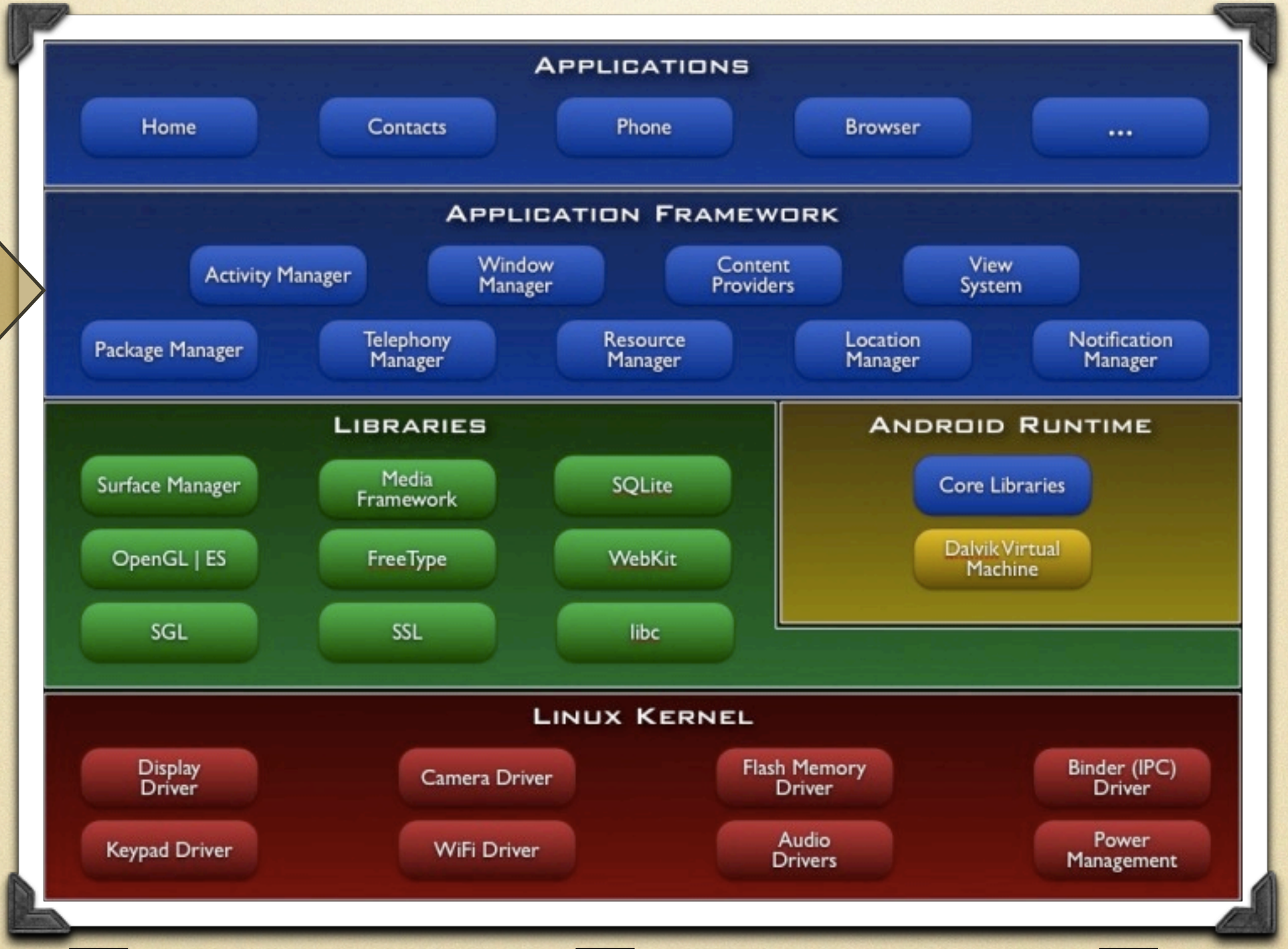

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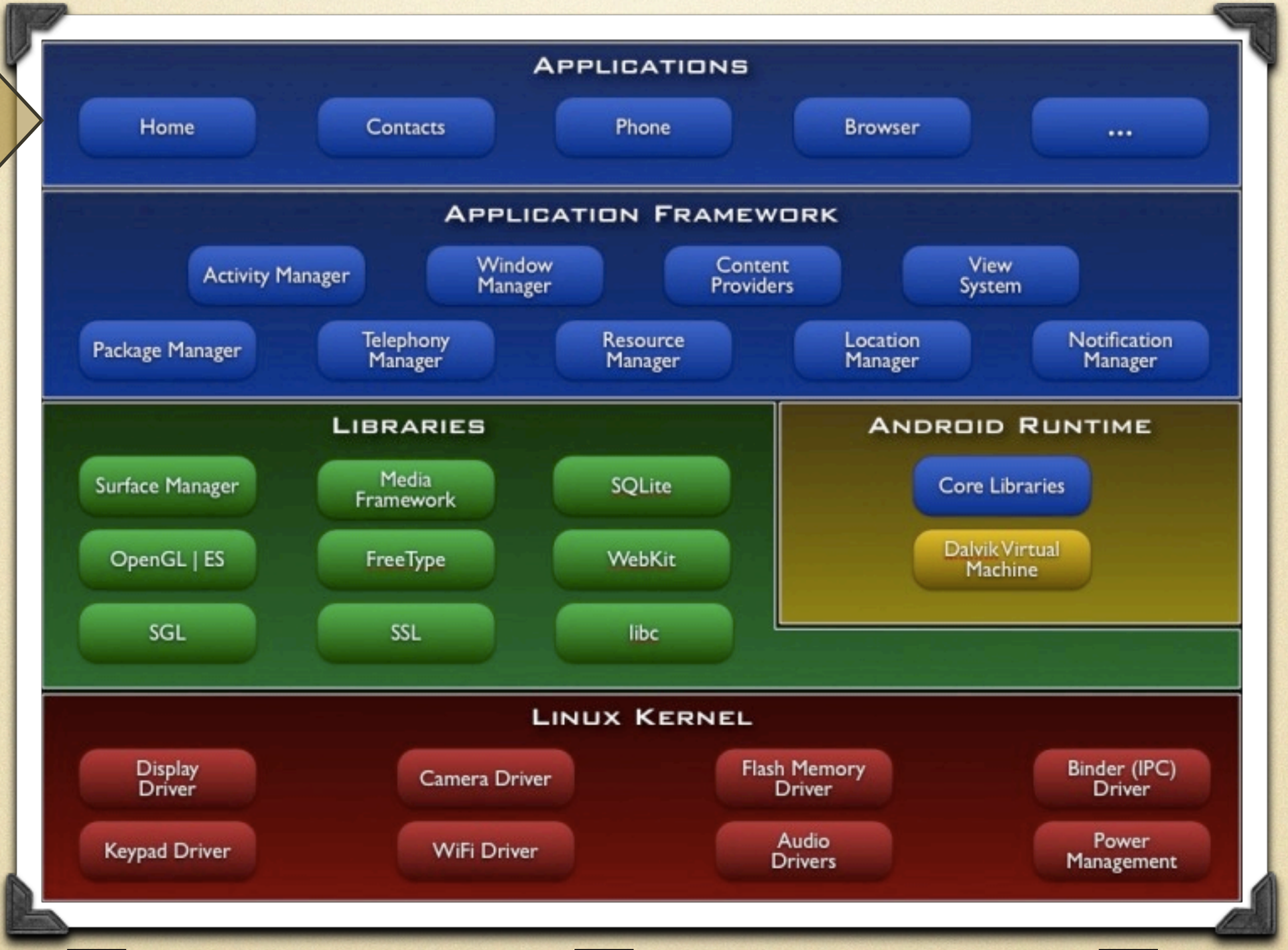

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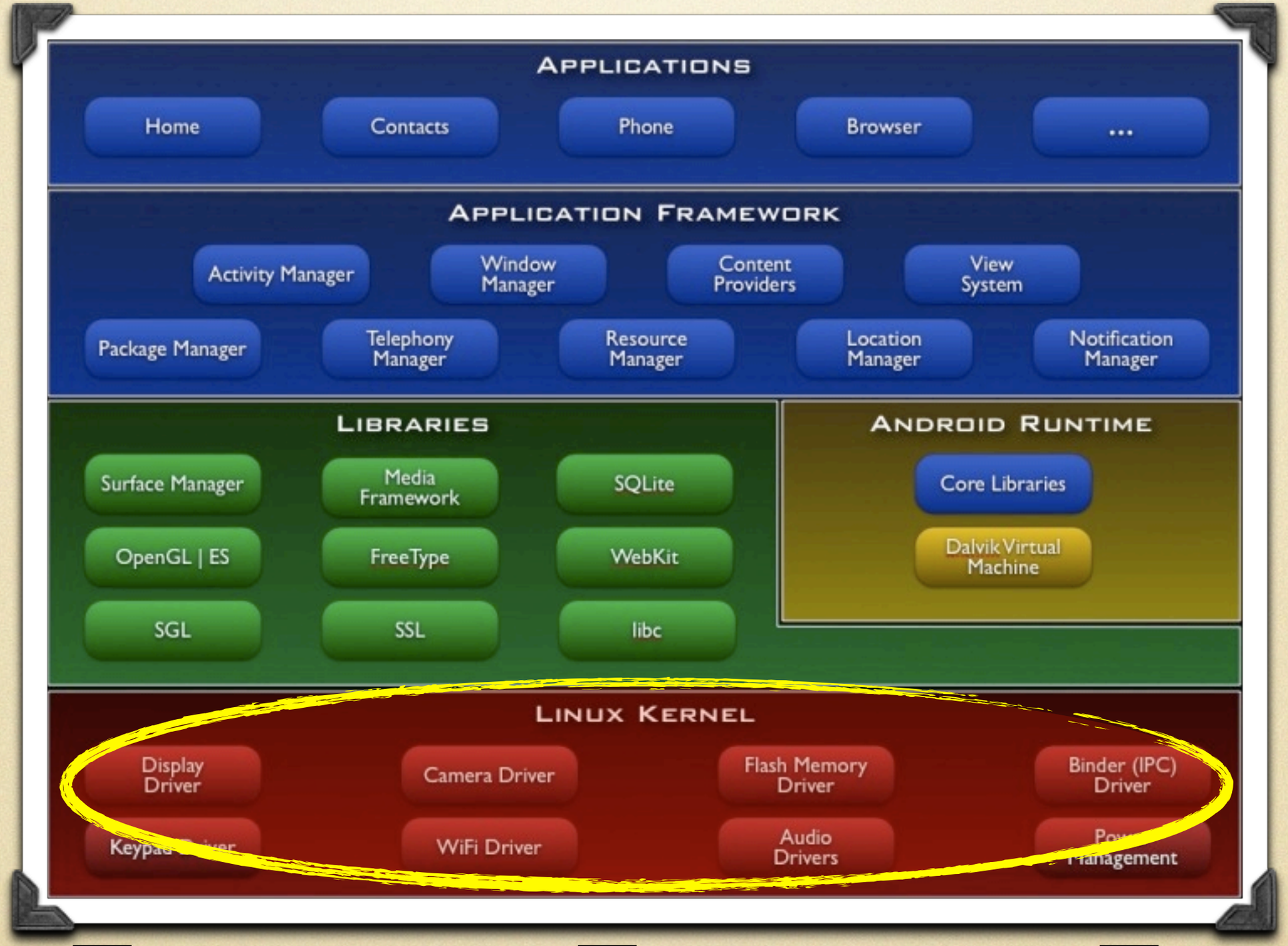

OS: C C/C++ Java

Overview

Overview

- system calls / processes

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- system calls / processes
- synchronization

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- scheduling

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- system calls / processes : zygote / Java workers
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- virtual memory : COW multi-process working set
- file systems : auto geo-tagging

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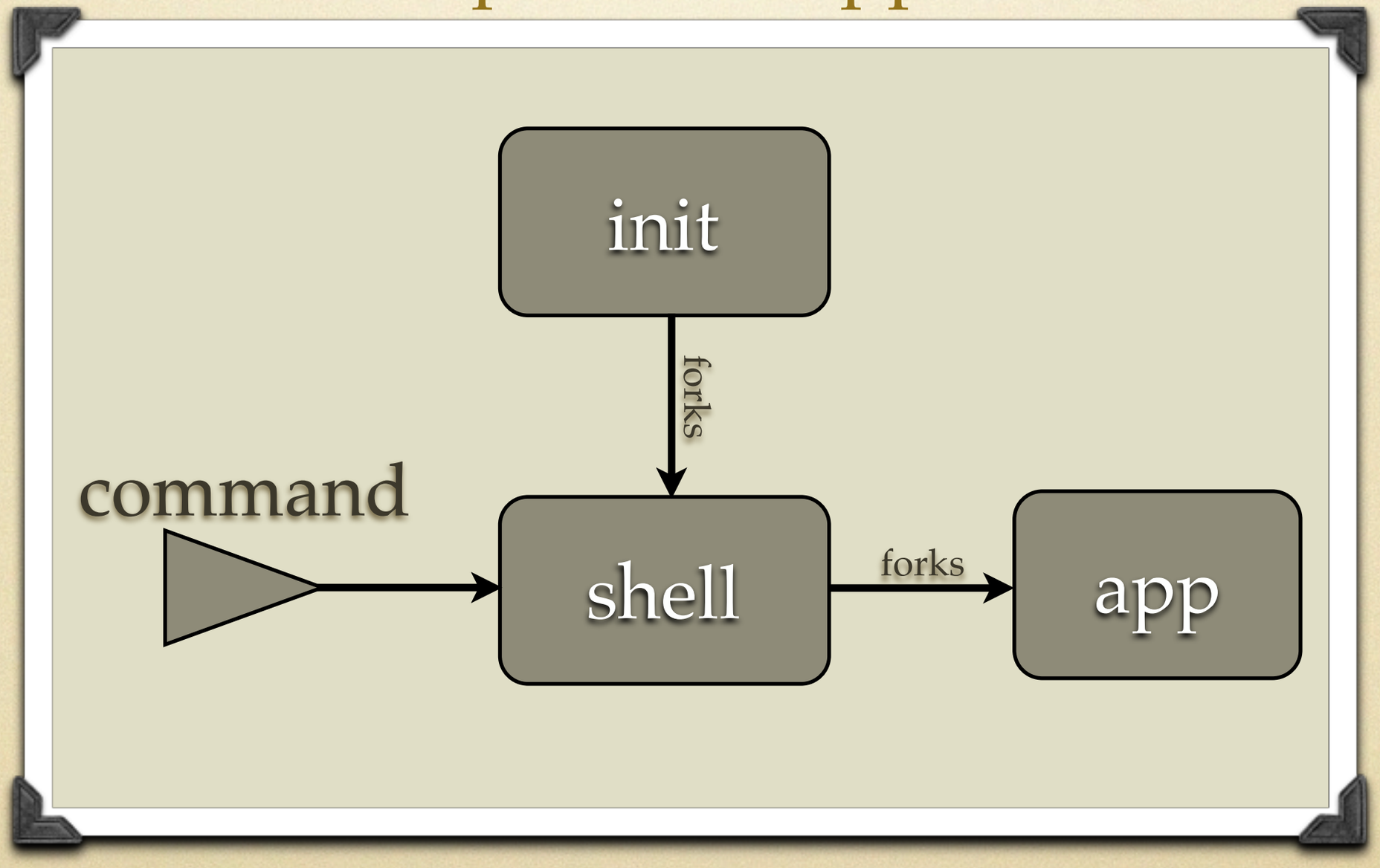
System Calls / Processes

System Calls / Processes

Linux desktop/server application start:



System Calls / Processes

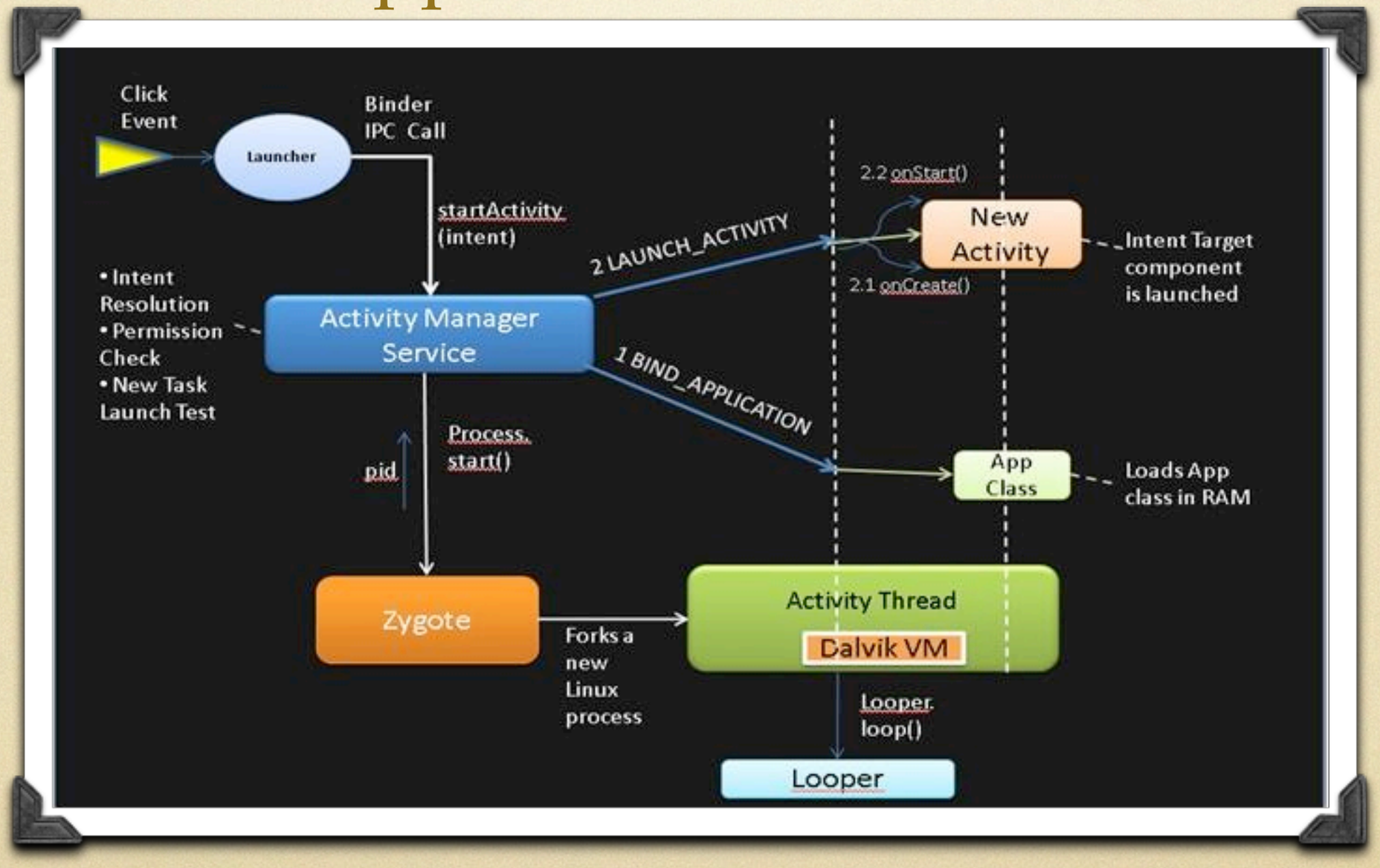
Linux desktop/server application start:

System Calls / Processes

Android application start:

System Calls / Processes

Android application start:



System Calls / Processes

Android application start:

System Calls / Processes

- new system call
- return process tree in DFS order
- simple user space test program
- reflect on benefits of zygote process

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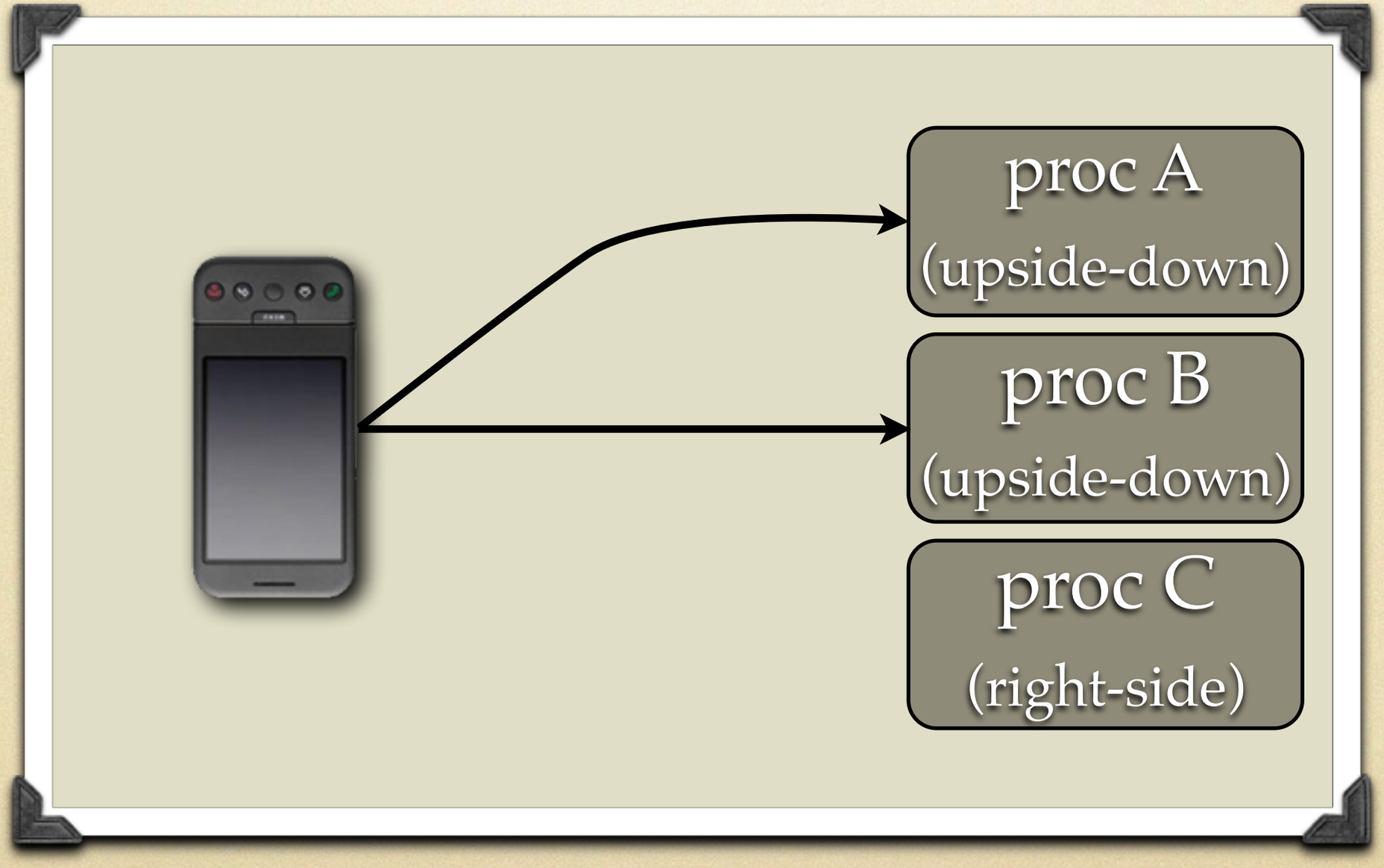
proc A
(upside-down)

proc B
(upside-down)

proc C
(right-side)

Synchronization



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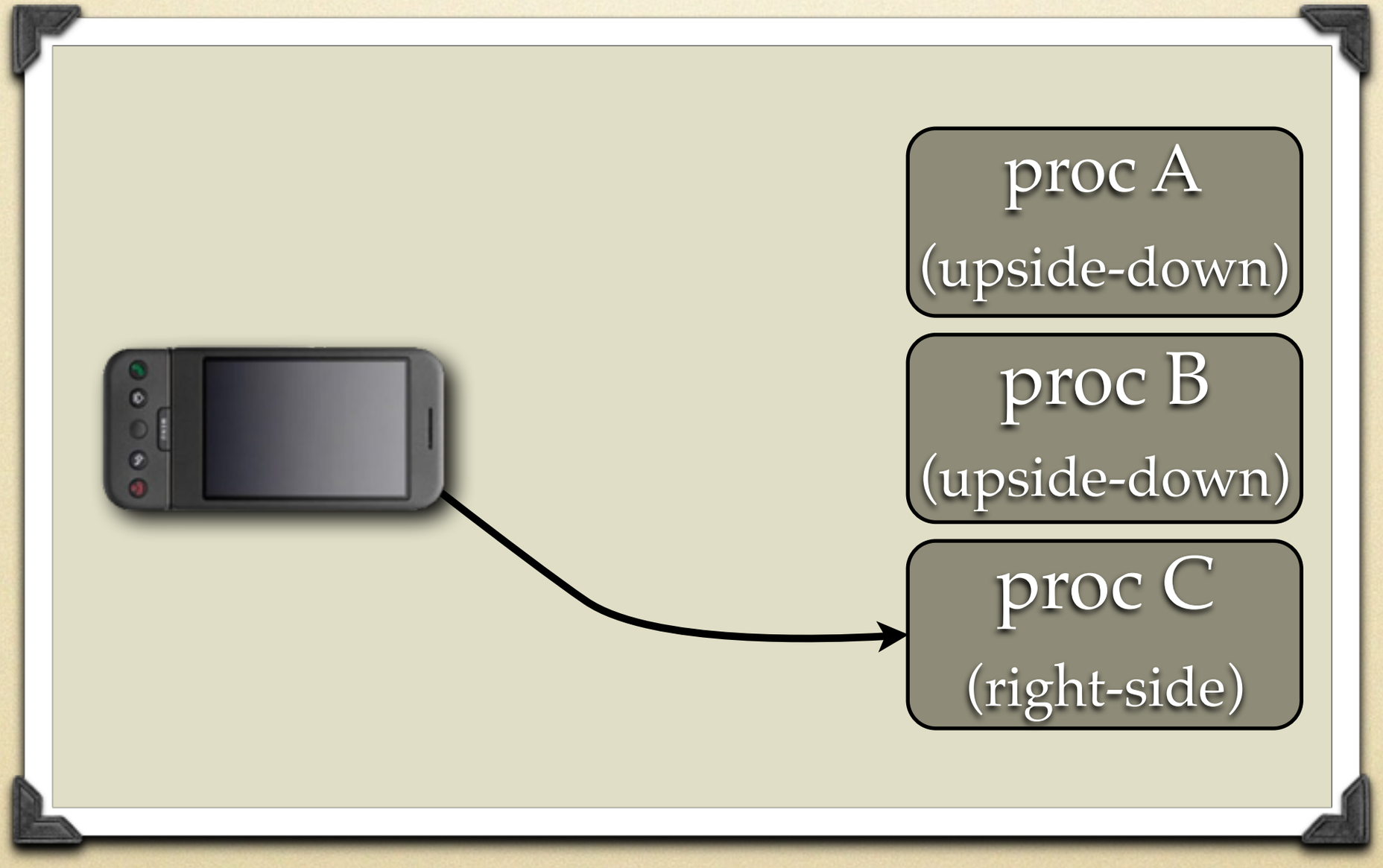

Synchronization

proc A
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Synchronization

- user space daemon to read orientation (library)
- new syscall to update orientation in kernel
- new orientevt open/close/wait syscalls
- investigate HAL layer, use real sensor data

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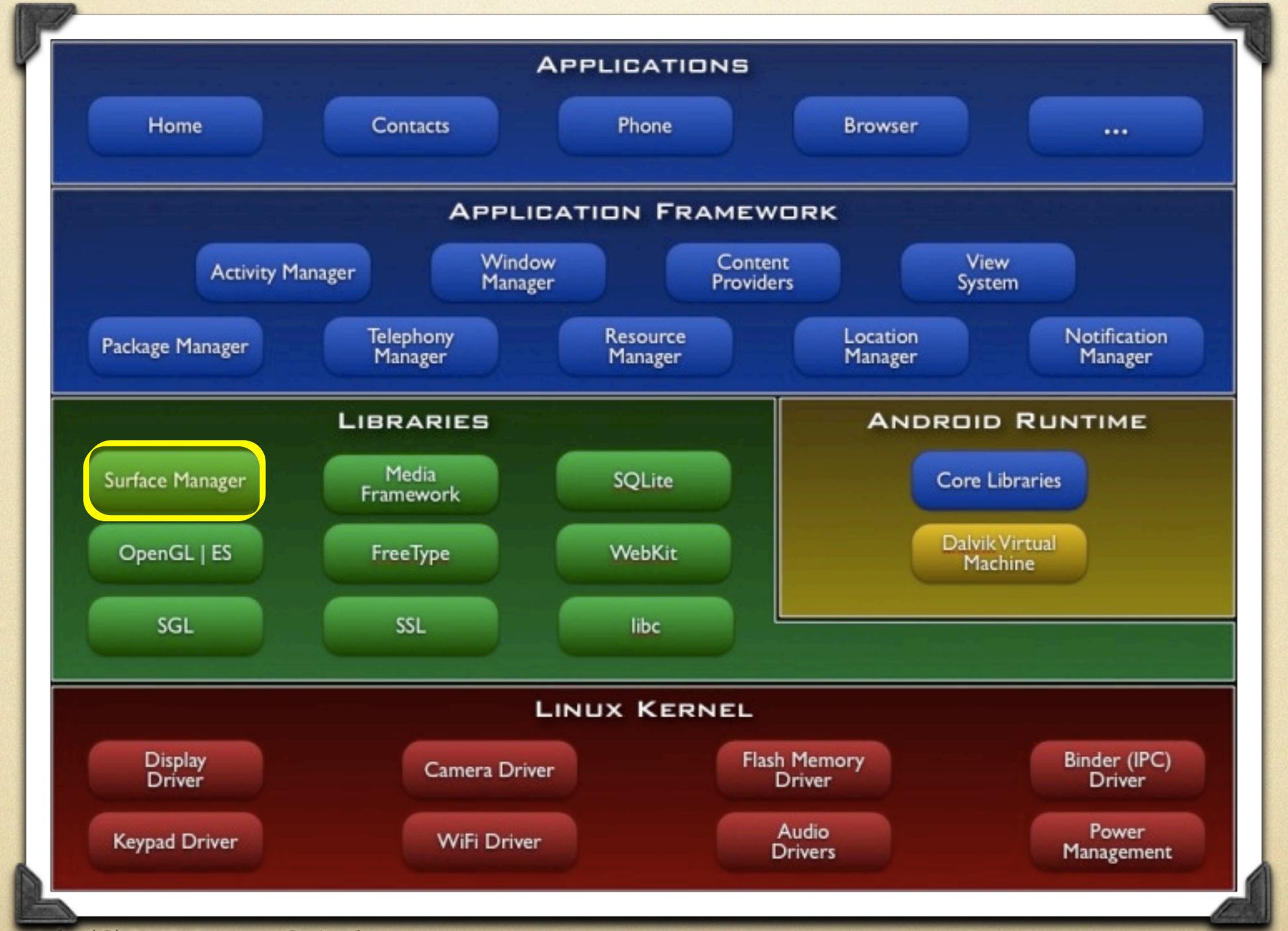

Scheduling

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- drawing == interactive

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- display boosted multi-level container (DBMC)

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- 15-line patch to core Android drawing library

Scheduling

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- display boosted multi-level container (DBMC)
- 15-line patch to core Android drawing library
- GUI boots 5-10s faster / network is slower

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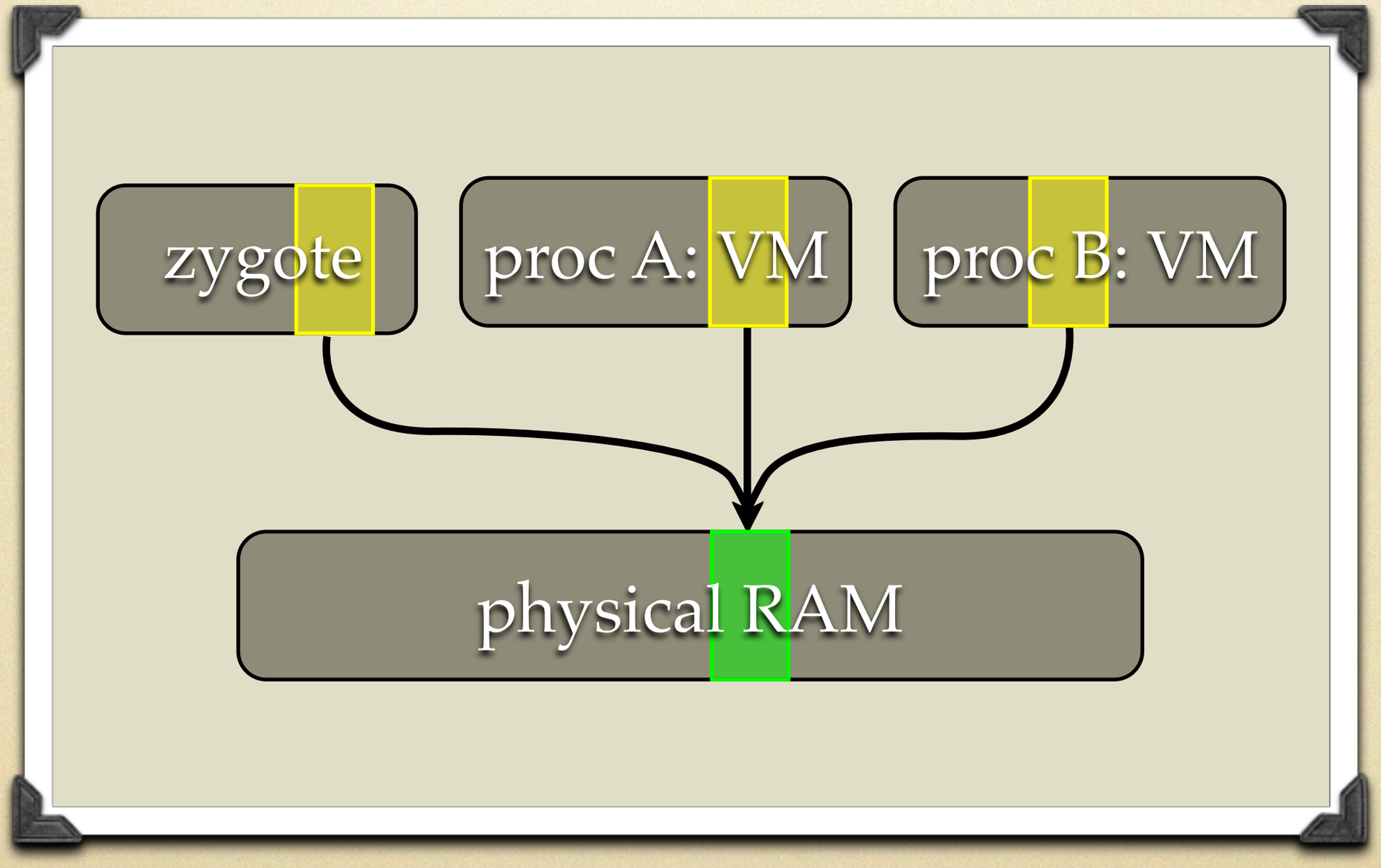

Virtual Memory

Virtual Memory

- zygote: quiescent VM waiting to be forked
- Android apps are forked from zygote
- cross-process working set: COW pages from zygote
- lots of shared memory + faster app startup

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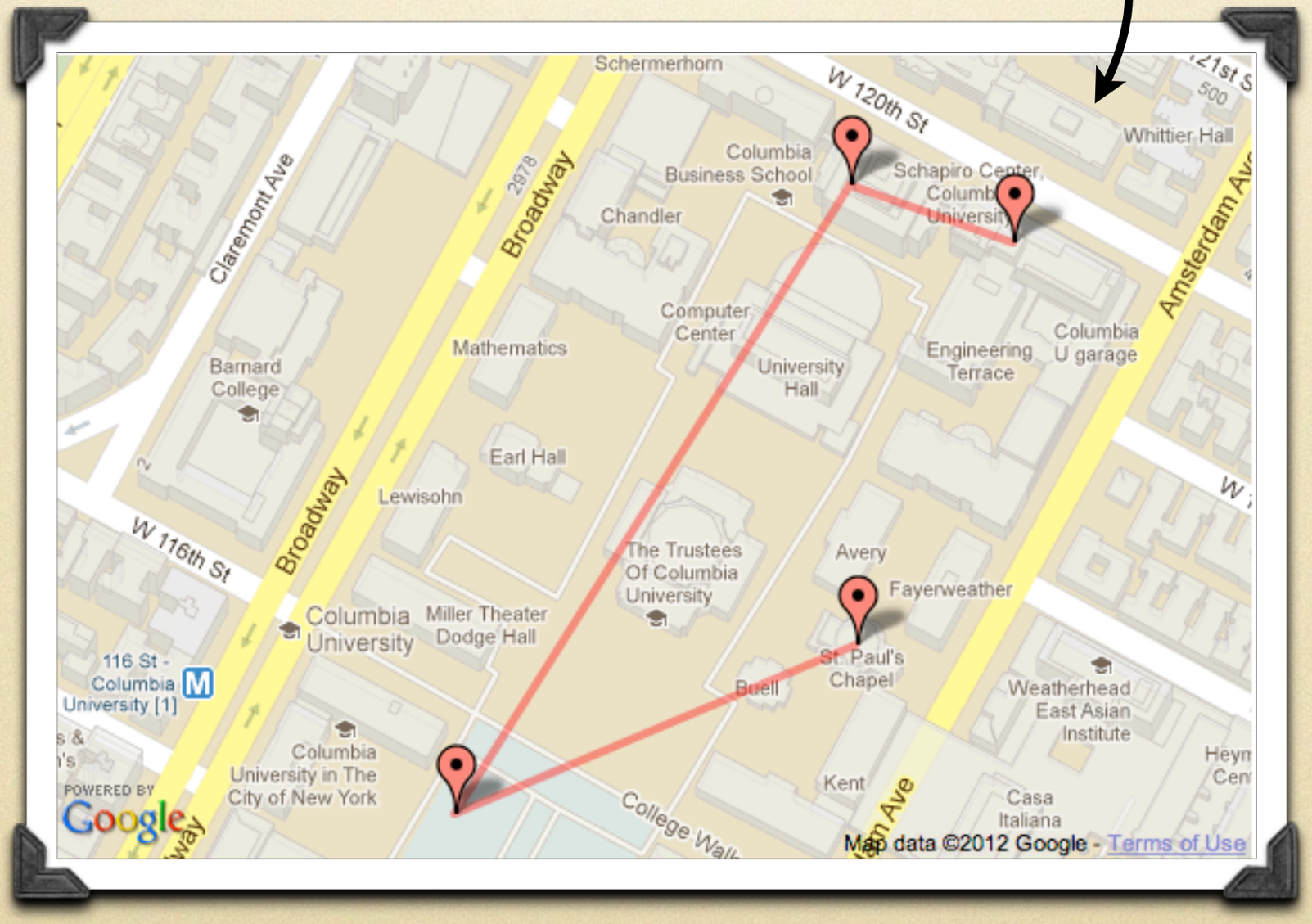
File Systems

File Systems

```
echo “HERE” > `date +”%s”`.txt
```

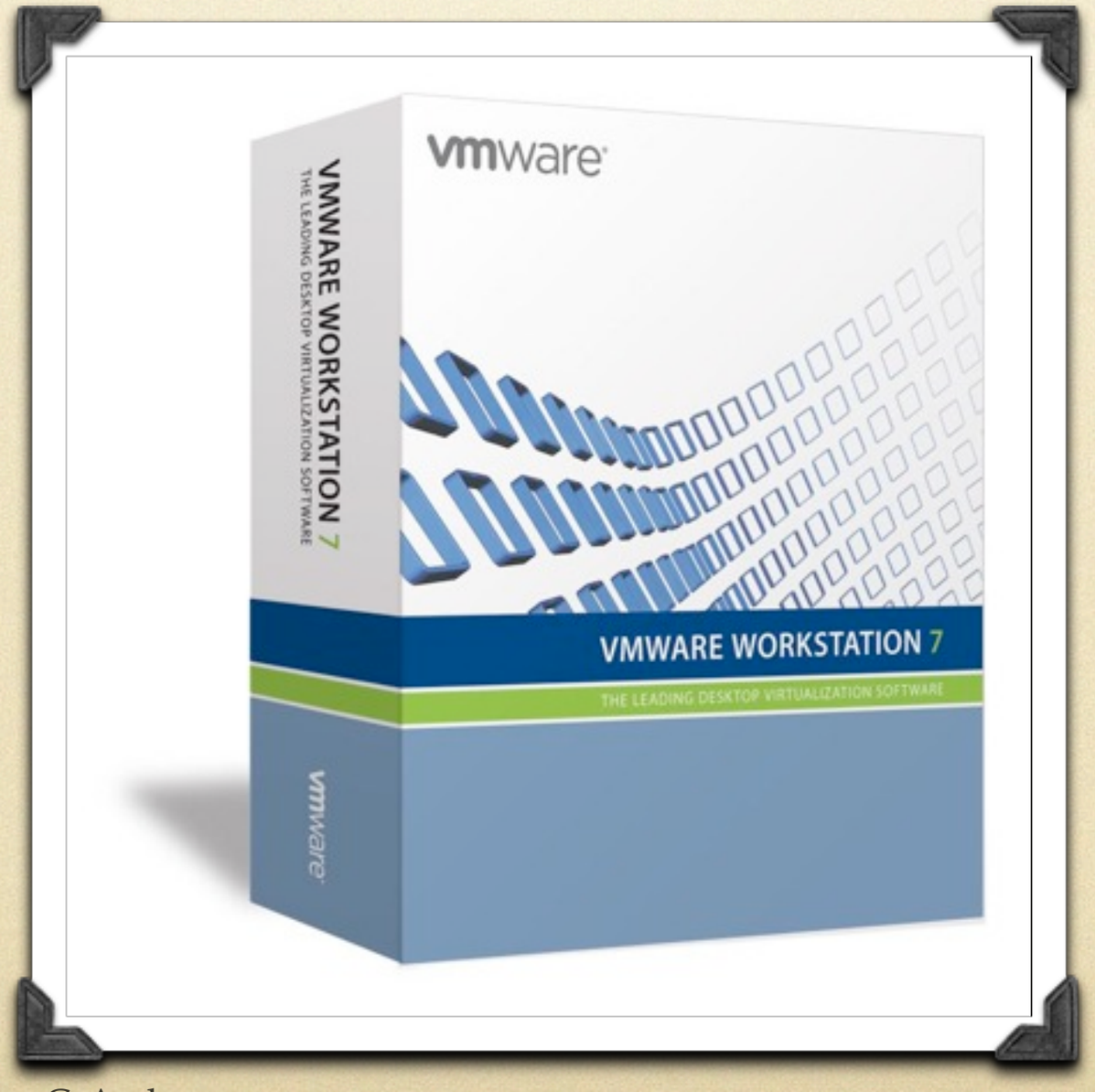


File Systems

- user space daemon updates GPS coordinates
- modify ext2 file system
- last-known GPS location on create/modify
- Google Maps link using system call to retrieve geo-location

Virtual Machines

fully-configured cross-compilation tools



Virtual Machines

fully-configured cross-compilation tools

Real Cell Phones

Real Cell Phones

Unlocked Google ADP1 (T-Mobile G1)

Full-System Emulator

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QEMU based program bundled with Android SDK!

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git

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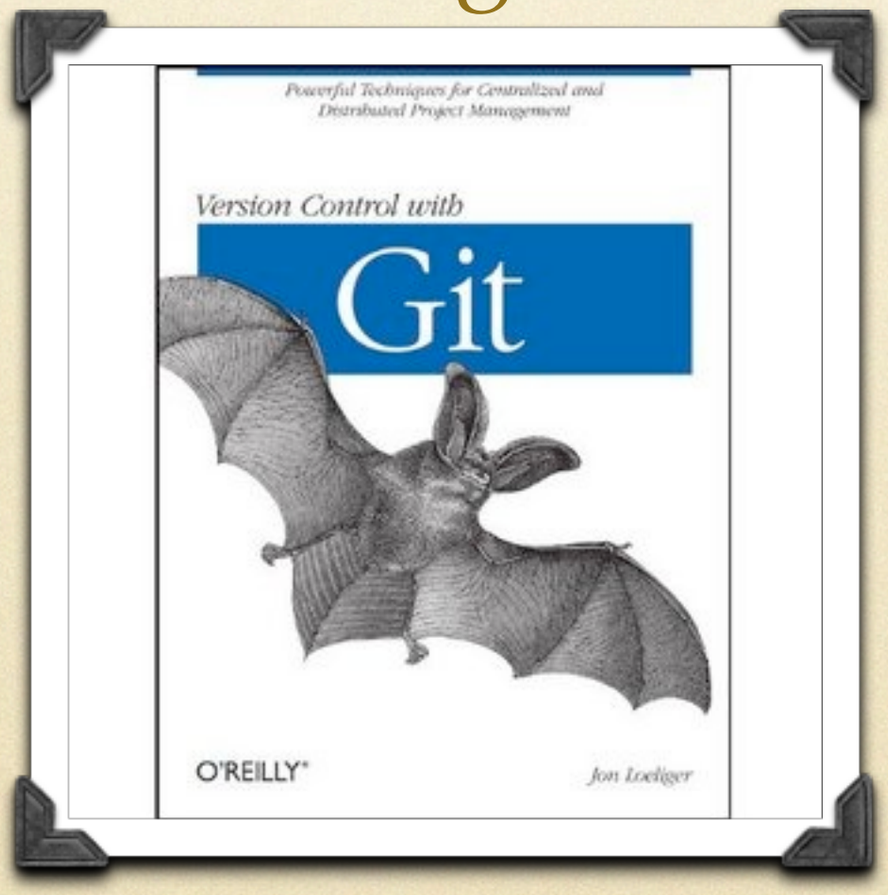
production grade SCM



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Show Your Work

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- hour-long demo slots (3-4 teams)

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- hour-long demo slots (3-4 teams)
- clone and build: your kernel must boot!
- code review
- demonstrate fully-functional solution

- deployed kernel assignments, virtual lab

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- ~100 students: undergrad through PhD

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Survey Results

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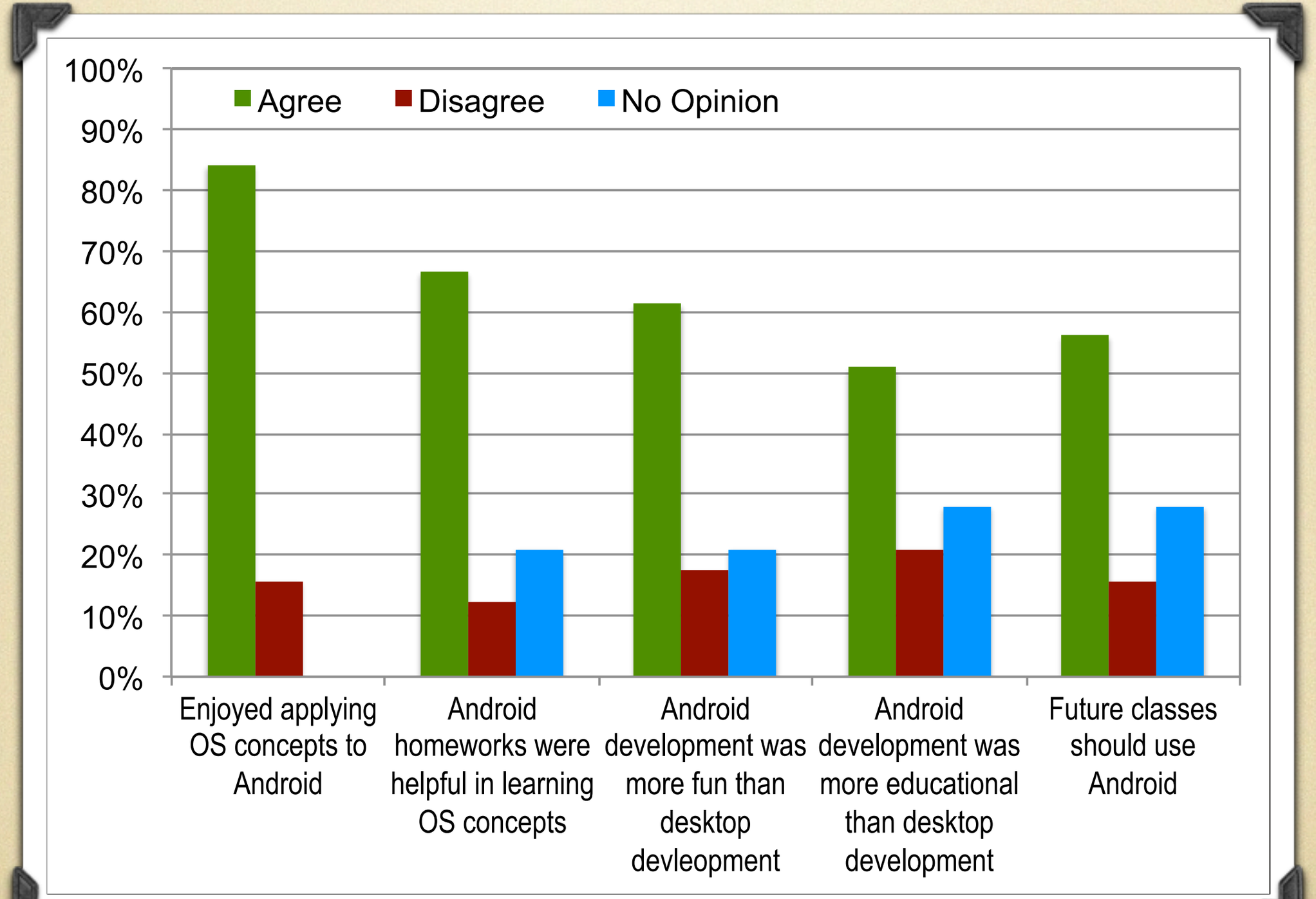

Survey Results

Lessons Learned

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- test before distributing assignments

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Lessons Learned

- test before distributing assignments
- difficult to keep emulator / device in sync
- need clear Android kernel debug documentation
- Android constantly evolves

Conclusions

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- Android is a great teaching tool

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- Android / mobile programming assignments

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- Android is a great teaching tool
- Android / mobile programming assignments
- Android virtual lab
- live demos

Conclusions

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- practical application outside classroom

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- practical application outside classroom
- can write “android development” on resume

Conclusions

- practical application outside classroom
- can write “android development” on resume
- students loved it!

http://systems.cs.columbia.edu/projects/teach-os/

http://www.cs.columbia.edu/~nieh/teaching/w4118/

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